

# Summary of Sensitivity Estimate for O4 in Various Interferometer Configurations

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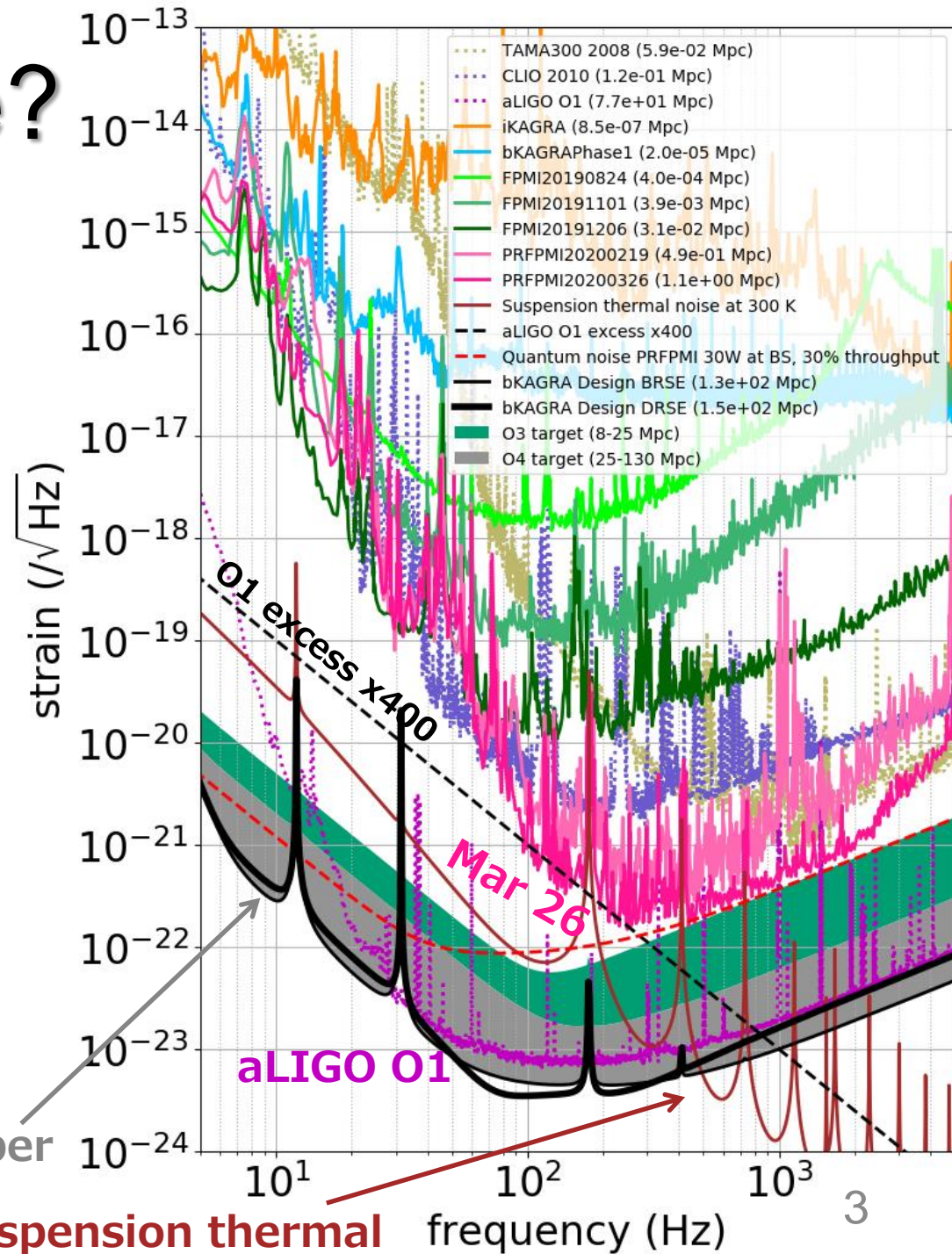
Kazuhiro Yamamoto

# Assumptions

- IFO configuration: PRFPMI with 0% SRM or DRFPMI with 70% SRM, upto 300 W at BS (no shot noise coupling considered)
- Temperature: 22 K to 300 K (heat extraction capability not considered); see [JGW-P2011614](#)
- Frequency and intensity noise: current level or estimated noise in [JGW-T1910352](#)
  - Assume ITMs are not replaced (see [JGW-G2011541](#))
- Actuator noise: Not significant for O4 if we do it right (see [JGW-T2011661](#))

# Where Are We?

- ~1 Mpc at best
- PRFPMI with 70% SRM tilted, 3-5 W to PRM, ~250 K, DC readout
- O1 excess x400
- Almost shot noise limited at high freq. (klog [#13560](#))



O4 target on Obs. Scenario Paper  
25-130 Mpc by ~2021

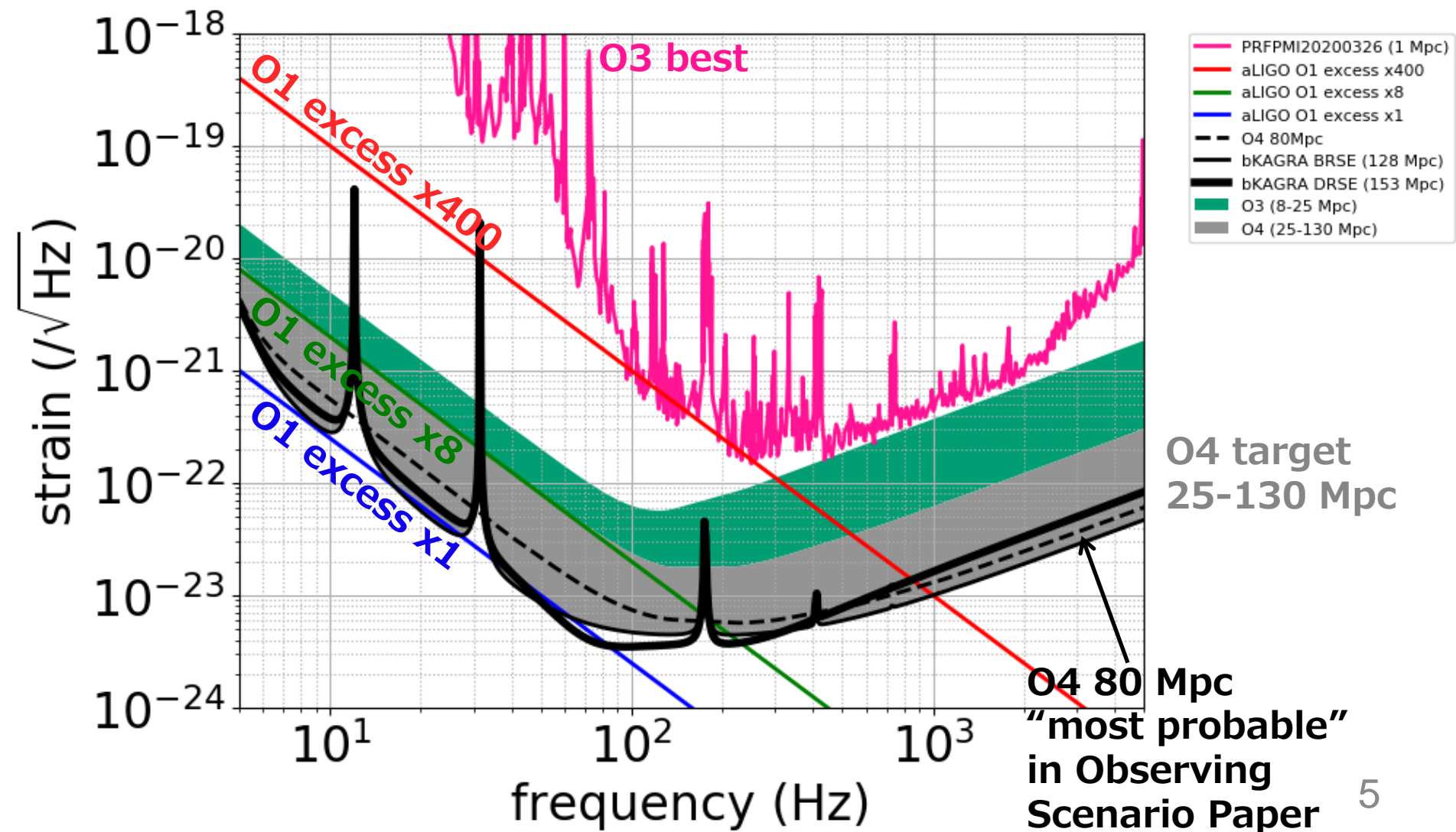
# O3 best and O4 Target

|                  | Mirror temp.  | Power at BS    | SRM reflectivity  | Detuning angle          | Homodyne angle                | Excess noise    |
|------------------|---------------|----------------|-------------------|-------------------------|-------------------------------|-----------------|
| <b>O3 best</b>   | <b>~250 K</b> | <b>30-50 W</b> | <b>70% tilted</b> | <b>~90 deg (PRFPMI)</b> | <b>~90 deg (conventional)</b> | <b>O1 x 400</b> |
| O3 low           | 22 K          | 10 W           | 0 %               | 90 deg (PRFPMI)         | 90 deg (conventional)         | O1 x 20         |
| O3-15Mpc         | 22 K          | 10 W           | 70 %              | 90 deg                  | 90 deg                        | O1 x12          |
| O3 high / O4 low | 22 K          | 33 W           | 70 %              | 90 deg (BRSE)           | 90 deg (conventional)         | O1 x 8          |
| <b>O4 80Mpc</b>  | <b>22 K</b>   | <b>404 W</b>   | <b>85 %</b>       | <b>90 deg</b>           | <b>90 deg</b>                 | <b>O1 x 2</b>   |
| O4 high          | 22 K          | 673 W          | 85 %              | 90 deg (BRSE)           | 90 deg (conventional)         | no excess       |
| Design           | 22 K          | 673 W          | 85 %              | 86.5 deg                | 135.1 deg                     | no excess       |

For details, see [JGW-T1809078](#)

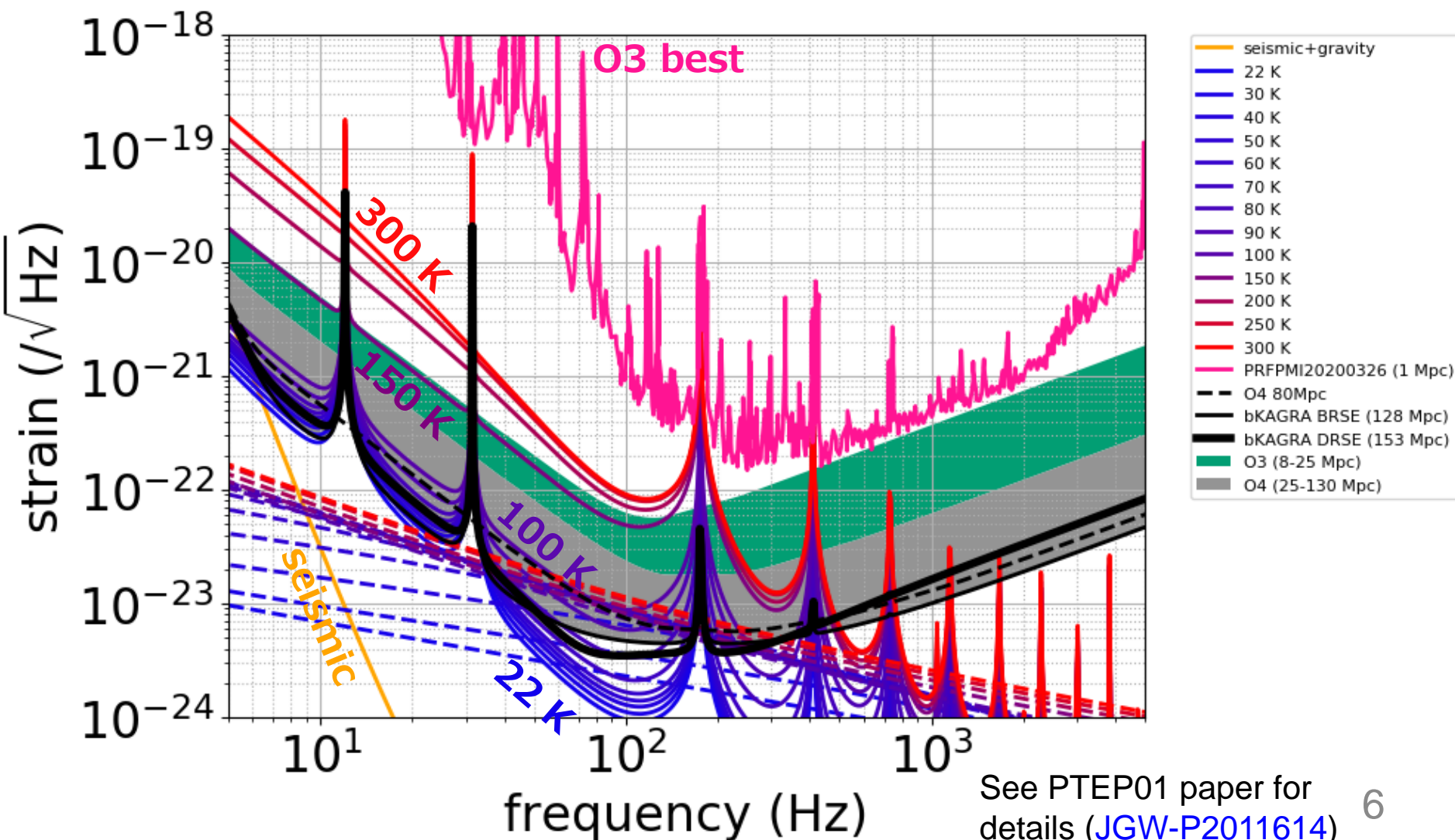
# O3 best and O4 Target

- Excess noise should be reduced by at least  $\sim 1/20$



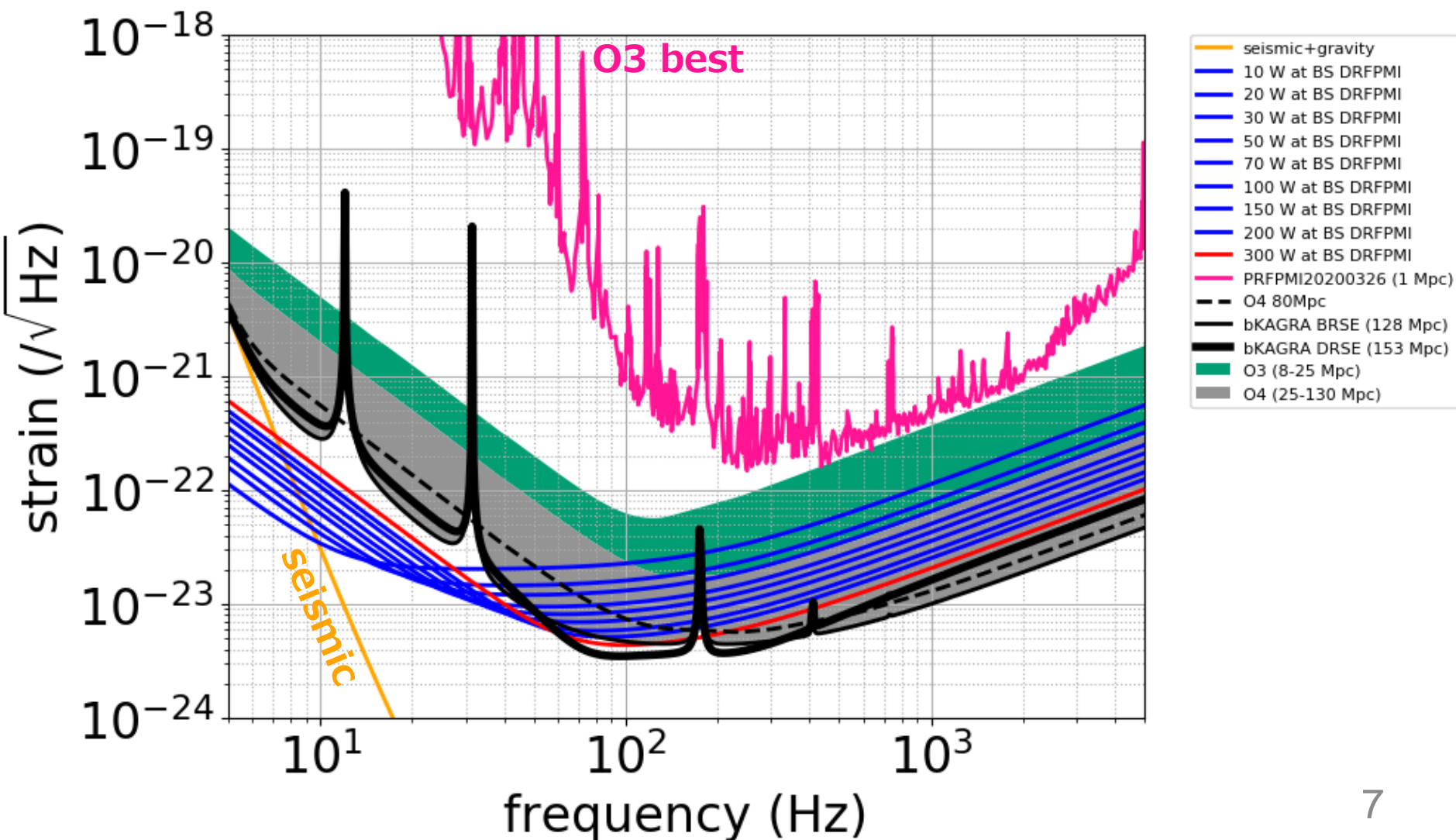
# Various Thermal Noise

- 150 K is not enough but 100 K could be OK



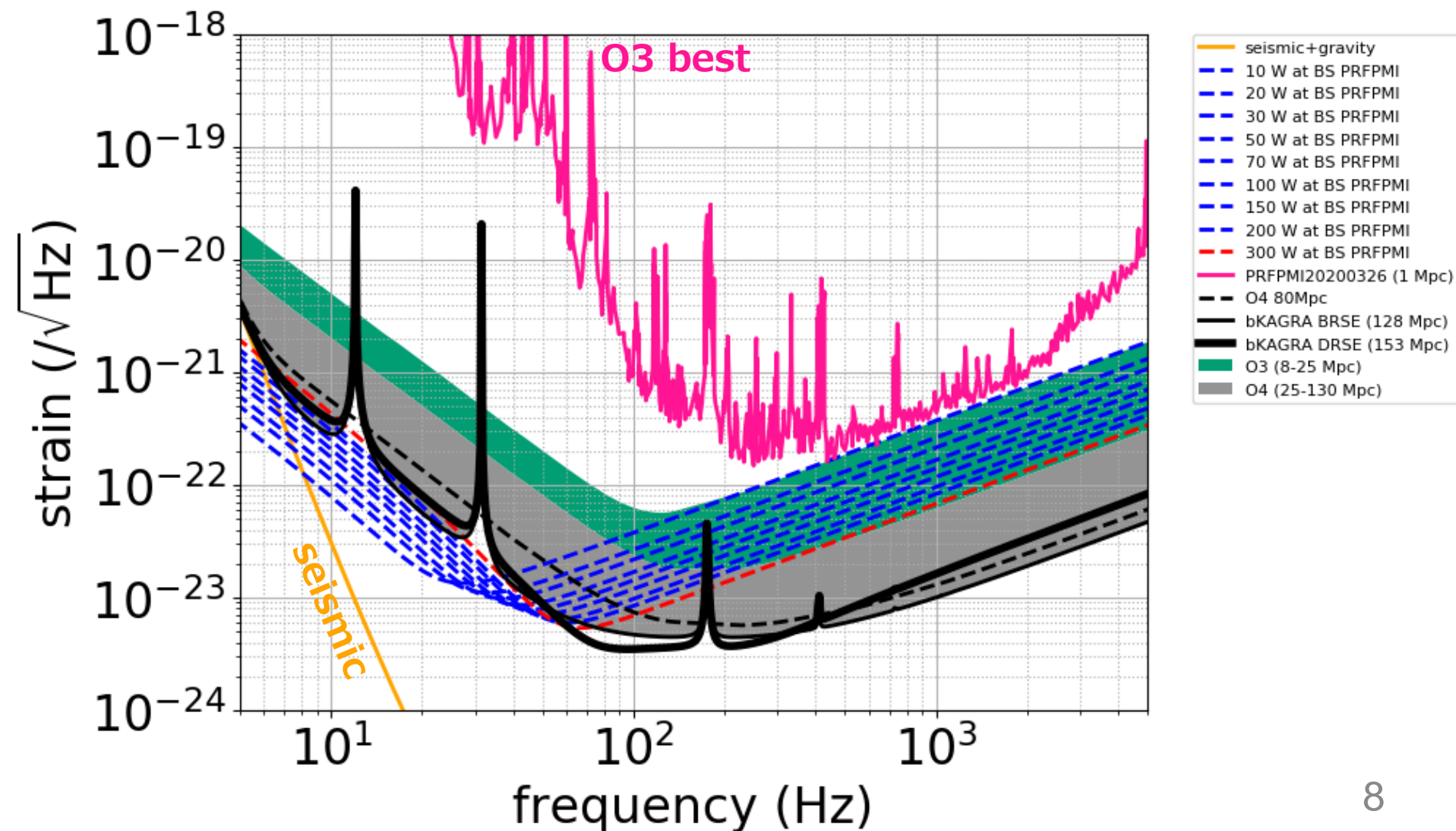
# Various Quantum Noise (DR)

- 30 W at BS would be OK



# Various Quantum Noise (PR)

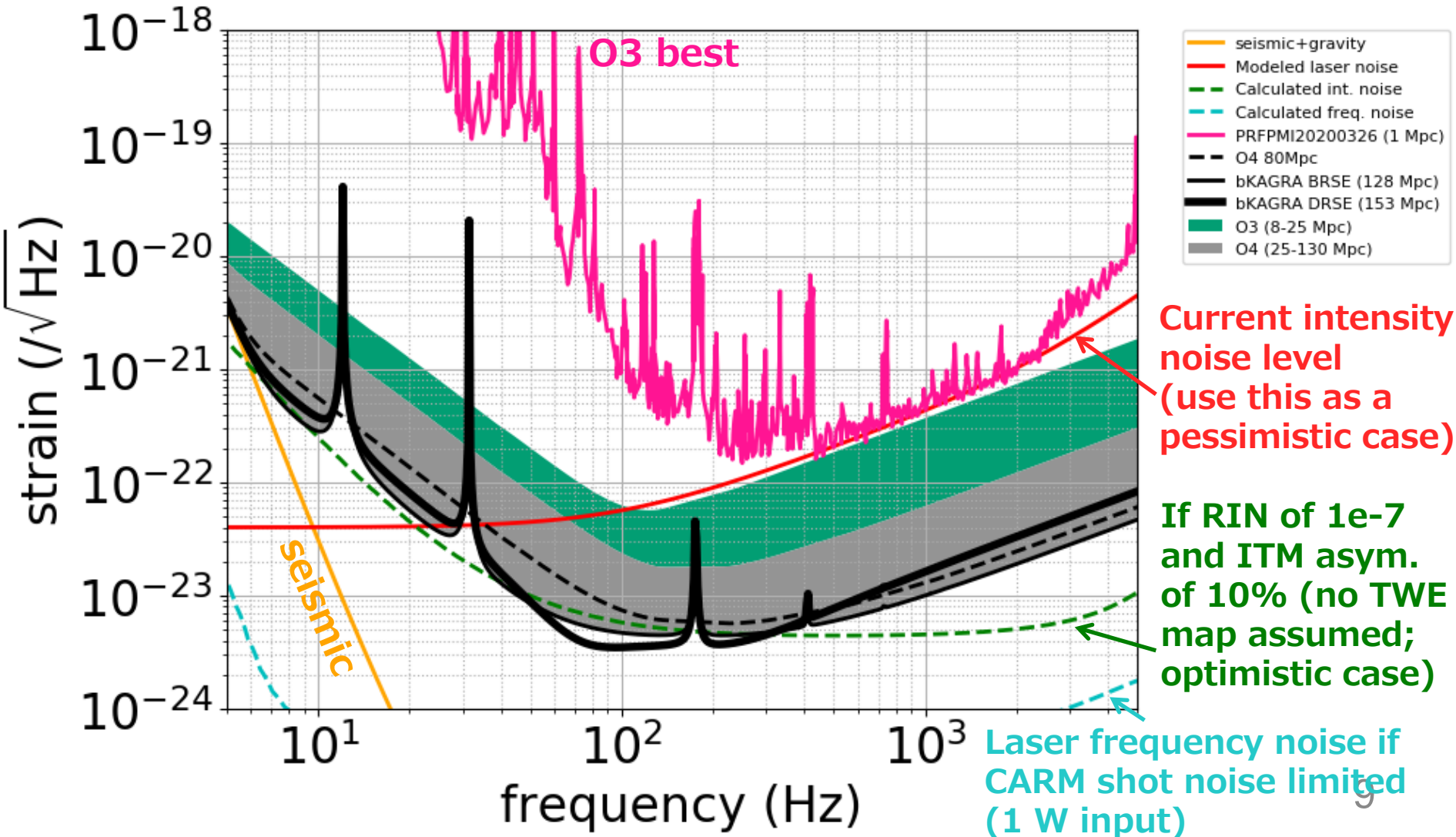
- High frequency sensitivity is not good





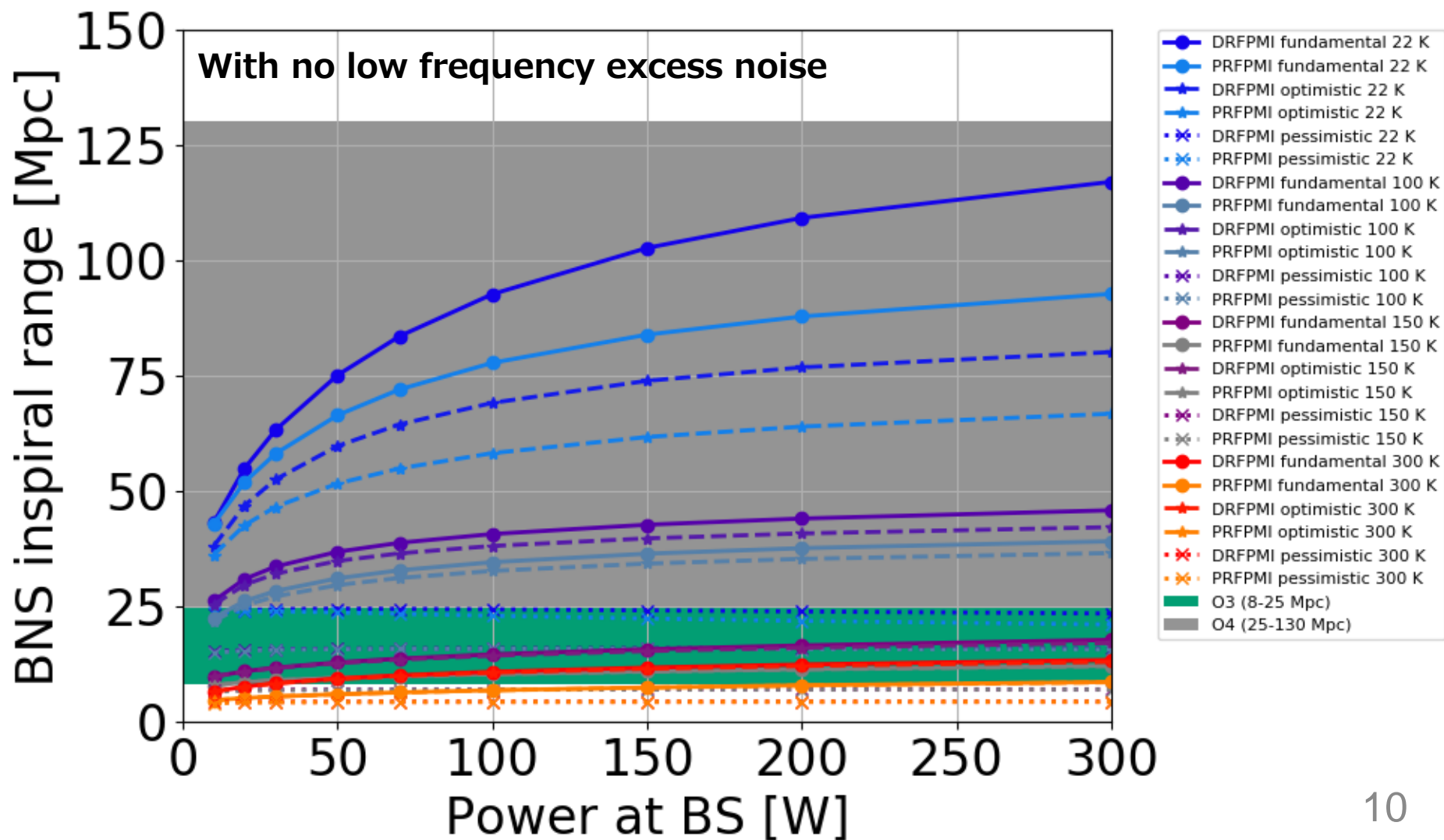
# Laser Noises

- Hard to predict without measurements



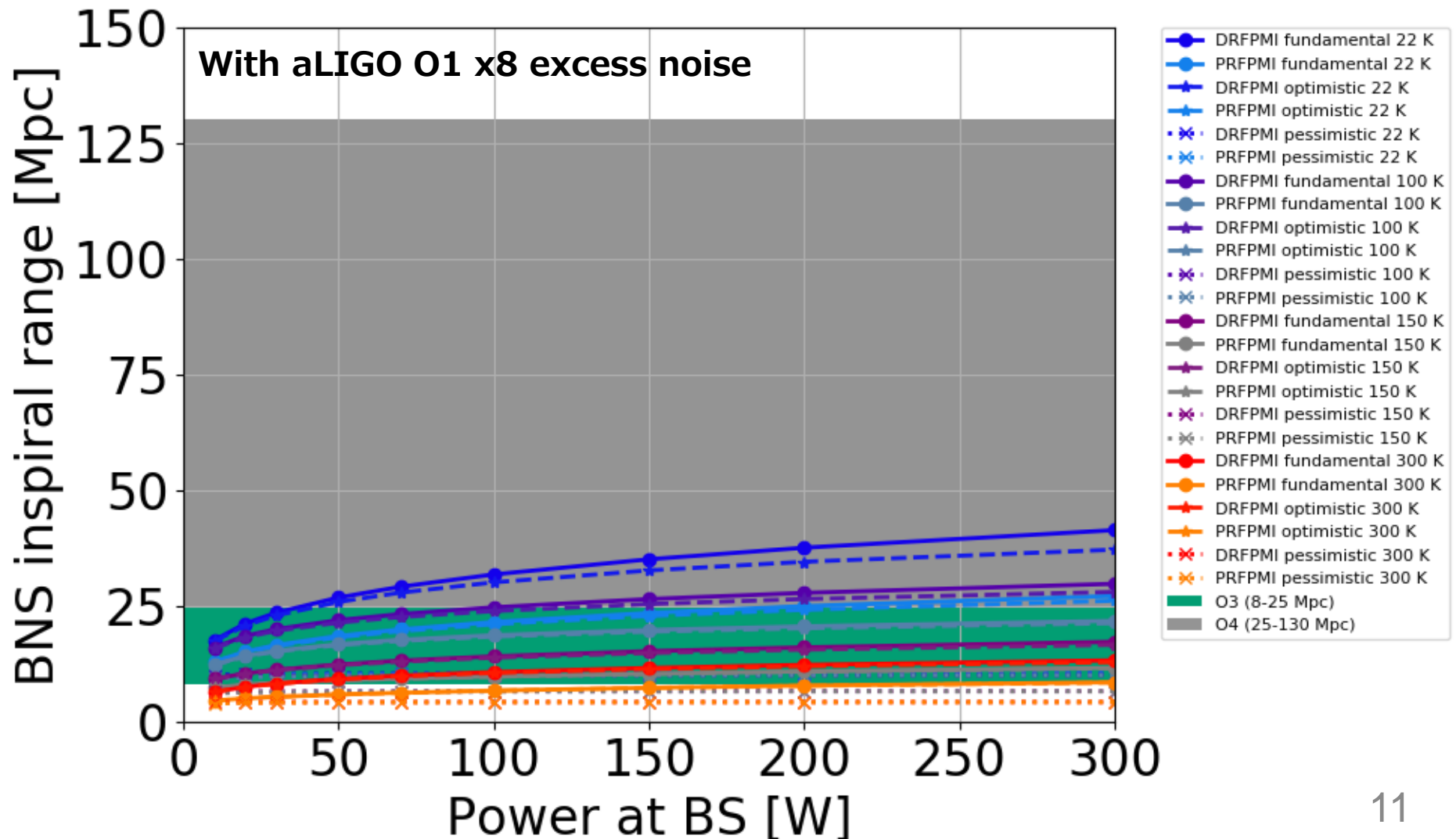
# Inspiral Range vs Power (x0 O1)

- Power change not so significant with other noises



# Inspiral Range vs Power (x8 O1)

- Power change not so significant with other noises



# Conclusions So Far

- Low frequency noise should be reduced at least by a factor of  $\sim 20$
- Should be below  $\sim 100$  K
- Higher power is better, but not so important especially when other noises are high
  - 30 W at BS could be enough
- As we have been keep saying, investigations on current noises are very important (low frequency noise; laser intensity and frequency noise) for estimating the sensitivity in O4